Listing of Claims:

This listing of claims will replace all prior versions and listings of claims in the application:

1. (Currently Amended) A system for estimating the position, velocity and orientation of a vehicle, comprising:

- ~~means for determining the components of two noncollinear constant unit vectors $\hat{g}_b, \hat{e}_b$ according to vehicle body axes, said means including:~~

  - an Inertial Measurement Unit (IMU) including a group of at least three gyroscopes for measuring the angular velocity $\hat{\omega}_b(t)$ of the vehicle in body axes and at least three accelerometers located along the vehicle body axes to provide the specific force $\hat{a}_b$ in body axes;

  - a magnetometer able to measure the Earth's magnetic field according to the vehicle body axes;

  - static pressure and differential pressure sensors;

  - two vanes to measure the angles of attack and side slip;

  - an angular velocity acquisition and processing module configured to acquire the angular velocity $\hat{\omega}_b(t)$ and delay it to obtain $\hat{\omega}_b(t-\tau)$;

  - a data acquisition and processing module configured to acquire the specific force $\hat{a}_b(t)$ measured by the accelerometers, the static pressure $\hat{p}_s(t)$ measured in sensor, the differential pressure $\hat{p}_d(t)$ measured in sensor, the angle of attack $\hat{\alpha}(t)$ measured in sensor, the angle of sideslip $\hat{\beta}(t)$ measured in sensor and the value of the Earth's magnetic field $\hat{m}_b(t)$ measured in the magnetometer, delay them and process them to calculate the true airspeed $\hat{\upsilon}(t-\tau)$, the air velocity in body axes $\hat{v}_b(t-\tau)$ as follows:

$$\hat{v}_b = \begin{bmatrix} \hat{\upsilon}\cos\hat{\alpha}\cos\hat{\beta} \\ \hat{\upsilon}\sin\hat{\beta} \\ \hat{\upsilon}\sin\hat{\alpha}\cos\hat{\beta} \end{bmatrix},$$

the numerical derivative of the air velocity in body axes $\dot{\hat{v}}_b(t-\tau)$,

the local gravity in body axes $\hat{g}_b$ as follows:

$$\hat{g}_b(t-\tau) = \dot{\hat{v}}_b(t-\tau) + \hat{\omega}_b(t-\tau) \times \hat{v}_b(t-\tau) - \hat{a}_b(t-\tau)$$

and the projection of the Earth's magnetic field on the horizontal plane perpendicular to local gravity $\vec{e}(t-\tau)$ as follows:

$$\hat{e}_b(t-\tau) = \hat{m}_b(t-\tau) - \hat{m}_b(t-\tau) \cdot \frac{\hat{g}_b(t-\tau)}{|\hat{g}_b(t-\tau)|};$$

- a GPS receiver for determining the components of ~~said~~ two noncollinear constant unit vectors $\vec{g}_t, \vec{e}_t$ according to the Earth's axes; wherein the data provided by the GPS are acquired, processed and used in the data acquisition and processing module to calculate said components $\vec{g}_t, \vec{e}_t$;

~~wherein the system comprises~~

- a module for correcting said angular velocity $\hat{\omega}_b$ with a correction u_ω and obtaining a corrected angular velocity $\hat{\omega}_b = \hat{\omega}_b + u_\omega$;
- a module for integrating the kinematic equations of the vehicle receiving the corrected angular velocity $\hat{\omega}_b$ as input and providing the transformation matrix $\hat{B}$ for transforming Earth's axes into vehicle body axes and the orientation of the vehicle in the form of Euler angles $\hat{\Phi}$;
- a synthesis module of the components in body axes of the two noncollinear constant unit vectors to provide an estimation of said noncollinear vectors in body axes $\hat{g}_b, \hat{e}_b$, where said estimation is calculated as follows:

$$\vec{g}_b = B\vec{g}_t$$
$$\vec{e}_b = B\vec{e}_t$$

- a control module implementing a control law to calculate said correction u_ω, where said control law is:

$u_\omega = \sigma(\bar{g}_b \times \hat{g}_b + \bar{e}_b \times \hat{e}_b)$ [1]

where σ is a positive scalar,

such that by applying this correction u_ω to the measured angular velocity $\bar{\omega}_b$ and using the resulting angular velocity $\hat{\omega}_b = \bar{\omega}_b + u_\omega$ as input to the module for integrating the kinematic equations, the latter are stable in the ISS sense and the error in the estimation of the direction cosine matrix $\hat{B}$ and of the Euler angles $\hat{\Phi}$ is bounded.

2. (Previously Presented) The system according to claim 1, wherein said noncollinear unit vectors $\vec{g},\vec{e}$ are local gravity $\vec{g}$ and projection of the magnetic field on the plane perpendicular to gravity $\vec{e}$.

3 – 4. (Canceled)

5. (Currently Amended) The system according to claim 1, <u>further comprising</u> ~~wherein the system includes~~ a Savitzky-Golay filter where $\dot{\hat{v}}_b$, numerical derivative of $\hat{v}_b$, is calculated.

6. (Currently Amended) The system according to claim 1<u>, further comprising</u> ~~including~~:

- a navigation module where the navigation equations of the vehicle are integrated from the specific force $\bar{a}_b$ and the direction cosine matrix $\hat{B}$ to obtain calculated position and velocity in local axes and corrected in a Kalman filter to obtain estimated position and velocity in local axes.

7. (Previously Presented) A method for estimating the position, velocity and orientation of a vehicle comprising:

- calculating the components of two noncollinear constant unit vectors $\bar{g}_b,\bar{e}_b$ according to vehicle body axes from measurements of sensors located in the

vehicle according to the body axes of the latter, said calculation comprising:

- measuring specific force $\hat{a}_b(t)$ in body axes, static pressure $\hat{p}_s(t)$, differential pressure $\hat{p}_d(t)$, angle of attack $\hat{\alpha}(t)$, angle of sideslip $\hat{\beta}(t)$ and the value of the Earth's magnetic field $\hat{m}_b(t)$;

- calculating the true airspeed $\hat{\upsilon}(t)$ from the differential pressure $\hat{p}_d(t)$ and static pressure $\hat{p}_s(t)$ measurements and from knowing the outside temperature at the initial moment T_0;

- calculating the air velocity in body axes as follows:

$$\hat{v}_b = \begin{bmatrix} \hat{\upsilon}\cos\hat{\alpha}\cos\hat{\beta} \\ \hat{\upsilon}\sin\hat{\beta} \\ \hat{\upsilon}\sin\hat{\alpha}\cos\hat{\beta} \end{bmatrix};$$

- delaying a time τ the angular velocity $\hat{\omega}_b(t)$, specific force $\hat{a}_b(t)$, magnetic field $\hat{m}_b(t)$ and air velocity in body axes $\hat{v}_b(t)$;

- calculating the numerical derivative of the air velocity in body axes $\dot{\hat{v}}_b(t-\tau)$;

- calculating the local gravity in body axes $\hat{g}_b$ as follows:

$$\hat{g}_b(t-\tau) = \dot{\hat{v}}_b(t-\tau) + \hat{\omega}_b(t-\tau)\times\hat{v}_b(t-\tau) - \hat{a}_b(t-\tau);\ \text{y,}$$

- calculating the projection of the Earth's magnetic field on the horizontal plane perpendicular to local gravity as follows:

$$\hat{e}_b(t-\tau) = \hat{m}_b(t-\tau) - \hat{m}_b(t-\tau)\cdot\frac{\hat{g}_b(t-\tau)}{\left|\hat{g}_b(t-\tau)\right|};$$

- calculating the components of said noncollinear constant unit vectors $\vec{g}_t, \vec{e}_t$, according to the Earth's axes from measurements of sensors located in the vehicle which provide position in Earth-fixed axes;
- measuring the three components of angular velocity $\hat{\omega}_b$ of the vehicle in body axes;
- correcting the angular velocity $\hat{\omega}_b$ with a correction u_ω and obtaining a

corrected angular velocity $\hat{\omega}_b = \overset{\frown}{\omega}_b + u_\omega$;

- integrating the kinematic equations of the vehicle, according to the corrected angular velocity $\hat{\omega}_b$ and providing the transformation matrix $\hat{B}$ for transforming the Earth's axes into vehicle body axes and the orientation of the vehicle in the form of Euler angles $\hat{\Phi}$;
- calculating an estimation of the components in body axes of the two noncollinear constant unit vectors $\hat{g}_b, \hat{e}_b$, where said estimation is calculated as follows:

$$\hat{g}_b = \hat{B}\vec{g}_t$$
$$\hat{e}_b = \hat{B}\vec{e}_t$$

- obtaining the correction u_ω by means of the control law:

$$u_\omega = \sigma(\overset{\frown}{g}_b \times \hat{g}_b + \overset{\frown}{e}_b \times \hat{e}_b) \qquad [1]$$

where σ is a positive scalar,

such that upon applying this correction u_ω to the measured angular velocity $\overset{\frown}{\omega}_b$ and using the resulting angular velocity $\hat{\omega}_b = \overset{\frown}{\omega}_b + u_\omega$ as input to the module for integrating the kinematic equations, the latter are stable in the ISS sense and the error in the estimation of the direction cosine matrix $\hat{B}$ and of the Euler angles $\hat{\Phi}$ is bounded.

8. (Previously Presented) The method according to claim 7, wherein said noncollinear unit vectors $\vec{g}, \vec{e}$ are local gravity $\vec{g}$ and projection of the magnetic field on the plane perpendicular to gravity $\vec{e}$.

9 – 10. (Canceled).

11. (Previously Presented) The method according to claim 7 ~~9~~, wherein $\hat{\dot{v}}_b$, the numerical derivative of $\overset{\frown}{v}_b$, is calculated in a Savitzky-Golay filter.

12. (Previously Presented) A method according to claim 7 including:

- integrating the navigation equations of the vehicle according to the specific force $\hat{a}_b$ and the direction cosine matrix $\hat{B}$ to obtain the calculated position and velocity in local axes and they are corrected in a Kalman filter to obtain estimated position and velocity in local axes.